Results: The tumour volume, assessed at the planning CTscan, had a median of 26.9ml range: 0,6-527,8ml. At the 1.-30.fr the tumour change between the visual and algorithm assessment obtained a 82-97% agreement (k=0,65-0,94). At the 30.fr. the tumour change between the visual and doctor assessment had a 89% agreement (k=0,70). Tumour shrinkage was observed in 12pts.
Furthermore, at the 30.fr, there was no statistically significant difference between the tumour-change assessment of the doctor(mean:19,2ml 95%CI:10, 1-36,2ml) and the algorithm (mean: 19,6ml 95%CI:10,5-36,5ml), p=0,85. At the 30.fr there was an 89% (24pts) observed agreement between the three methods. Overall only 1pt had tumour growth >5ml.
Conclusions: The inter-tester reproducibility of tumour-change between the three methods is good. The visual, doctor and algorithm assessments had an agreement of 89%. There was no statistically significant difference between the tumour-change assessment of the doctor and the algorithm. Visual inspection may be used to determine tumour shrinkage during the radiotherapy course.

OC-0072
Development and implementation of a non-invasive stereotactic head frame
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Purpose/Objective: To develop and implement a non-invasive head frame for intracranial stereotactic radiotherapy (SRT). While maintaining and improving treatment accuracy it was important to make the new SRT/SRS frame more efficient, more comfortable for the patients and easier to use for the therapists. We analyzed set up accuracy and intra-fractional motion of the new frame (Civco Medical systems) in comparison to the currently used system (BrainLab).
Materials and Methods: Twenty patients (140 fractions) were treated with the CIVCO SRS frame, 19 Patients (152 fractions) were treated with the Brainlab system. The CIVCO frame contains no metal parts making it MRI compatible. Additionally, it allows for better gantry clearance compared to the Brainlab system. Patients were treated either using a VMAT or IMRT technique. Image guidance was performed using CBCT. All positioning discrepancies were documented including pitch and roll. If pitch or roll was greater than 1.5° patient setup was repeated. Translational and rotational errors were corrected daily. A post treatment CBCT was acquired to analyse intra-fractional patient stability.
Results: The setup based on lasers and isocenter marks on the mask is equally accurate in both systems with an accuracy of approximately 2 mm. The uncertainty in longitudinal direction is slightly reduced with the CIVCO system compared to the Brainlab system. Analysis of the CBCTs showed an increased roll for the patients being fixed with the CIVCO system (CIVCO: -0.143° ± 1.403°, Brainlab:-0.020° ± 0.028°). This lead to an increased frequency of patient reset-ups due to a pitch value outside tolerance. The intra-fractional motion was small and comparable between both systems in lateral and longitudinal direction, but was significantly larger for the Brainlab system in vertical direction (CIVCO: -0.02 (±0.23) mm, Brainlab: VRT: -0.21 (±0.41) mm, $p<10^{-3}$). The observed systematic shift of the Brainlab mask in vertical direction is likely related to the sagging of the patient.
Conclusions: Intra-fractional motion with the CIVCO frame proved to be slightly less than with the Brainlab system while the pitch and roll deviations in initial setup proved to be marginally larger. Pitch and roll can be corrected easily with a 6 DOF table or by repositioning the patient. Future studies will include frame efficacy, handling and patient comfort.

OC-0073
A comparitive study of four commercial thermoplastic masks used in head and neck radiotherapy.
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Purpose/Objective: The aim of this study is to compare four different 5-point fixation commercial thermoplastic masks (A, B, C and D) in combination with two different kinds of head supports (a and b) and then verify witch combination has less margin of error to get the best immobilisation system.
Materials and Methods: 34 patients with head and neck cancer were treated by using Intensity Modulated Radiotherapy (IMRT) and Rapid Arc (RA) therapy on a Varian® linear accelerator with an On Board Imager (OBI) system. All patients had Image Guided Radiotherapy (IGRT) using kilovoltage (KV) and megavoltage (MV) images at fractions 1-2-3 and then weekly once the systematic errors had been corrected and the random errors were within departmental tolerances. In total 505 images were evaluated.
The KV-MV images were compared with Digital Reconstructed Radiographs (DRR) to define the patient translation in the vertical (anterior-posterior), longitudinal (cranial-caudal) and lateral (right-left) axis. Using these measurements, we calculated for each group the systematic (Σsyst) and random error (orandom).
To determine if there was a statistical significant difference between the different masks within one head support group, we used the Kruskal-Wallis ANOVA test. For the difference between the same type of mask but with different head supports, we used the Mann-Whitney U test.
Results: Evaluation of the 5-point thermoplastic fixation mask and head support (values are in centimeters).

Head support	a					b			
Type of mask	A	B	C	D	All masks	B	C	D	All masks
Number of patient	4	8	3	5	**20**	5	5	4	**14**
Number of sessions	63	92	38	122	**315**	86	58	46	**190**
Ant-Post									
Systematic error	0,09	0,13	0,05	0,41	**0,22**	0,14	0,09	0,19	**0,13**
Random error	0,21	0,22	0,30	0,24	**0,24**	0,23	0,19	0,16	**0,19**
Cran-Caud									
Systematic error	0,13	0,13	0,14	0,12	**0,12**	0,03	0,10	0,21	**0,12**
Random error	0,22	0,23	0,27	0,20	**0,22**	0,14	0,20	0,15	**0,16**
Ri-Le									
Systematic error	0,20	0,14	0,14	0,11	**0,15**	0,08	0,09	0,14	**0,11**
Random error	0,20	0,21	0,17	0,28	**0,22**	0,16	0,14	0,18	**0,16**

Mask A was stopped after four patients, because there were difficulties modulating and removing the mask from the patient's head. For this reason no patients were include with this mask and head support b.
Conclusions: The study showed us that there is no statistical significant difference in systematic and random error between mask A,B,C and D. There is also no statistical significant difference between the two head supports, but all systematic and random errors for head support b are equal or lower than for head support a.

OC-0074
Radiation therapist led quality assurance of a CT-MRI SIM localisation protocol for patients undergoing H&N RT
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Purpose/Objective: To assess the geometric accuracy, image quality and precision of image registration of a new CT/MR-SIM localisation protocol, for patients immobilised with the MR-compatible Type-S frame undergoing head and neck radiotherapy.
Materials and Methods: At our institution, Radiation Therapists routinely perform treatment planning CT and MRI scans, as well as CT-MR image registration. This retrospective quality assurance study is an RT-led review of the CT-MRI SIM localisation protocol for patients undergoing head and neck radiotherapy. T1/T2 FSE MR-SIM images from the base of brain to below the clavicles, fused with a planning CT were reviewed for twenty patients immobilized using the MR compatible Type-S system and imaged in the treatment position, using a novel open architecture coil array. For the effective FOV and the pulse sequences utilized, phantom measurements were performed to quantify system related residual geometric distortions after application of a 3D commercial gradient distortion correction algorithm. Image quality analysis was performed by assessing coverage and measuring SNR and CNR in ten anatomical structures routinely contoured for RT planning. This data was benchmarked against an initial commissioning study for the coil. Accuracy of MR-CT image fusion was assessed for different levels of the head and neck, by performing multiple local registrations (superiorly, mid and inferiorly) and assessing concordance of pre-defined anatomical points.
Results: For all cases reviewed, the localisation protocol routinely provided high resolution MR-SIM images with coverage from the base of brain to below the clavicles, in the treatment position. From phantom studies, residual distortions were found to be ≤1.0mm within a 10 cm radius and < 1.5 mm within a 15 cm radius of the scan centre.

Image registration accuracy was<2mm for all anatomic head and neck landmark displacements in the x, y and z direction relative to CT.
Image quality was found to be comparable to the commissioning benchmark. SNR data for T1 FSE and T2 FSE were not statically significantly different (p= 0.53, 0.10) from benchmark dataset. However, the benchmark configuration appears to provide more optimized signal across all anatomical structures. For superficial structures closer to the surface, e.g. parotid, the RT coil provides very high signal due to closer proximity of the coil (T1 FSE mean RT 126.1 v diagnostic 99.8). For deeper structures the converse is true, e.g. brainstem (mean SNR RT 33.7 v diagnostic 58.2).
Conclusions: Benchmarking of the system and clinical process has allowed for the development of an MR-SIM quality assurance program for this anatomical site, with well defined imaging and image registration metrics.

PROFFERED PAPERS: PREVENT 1: MODELLING AND PREDICTION OF NORMAL TISSUE RESPONSE

OC-0075
Normal tissue complication probability parameters for breast fibrosis: pooled results from two randomised trials
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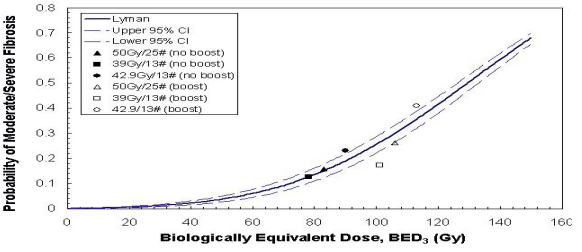
Purpose/Objective: The dose-volume effect of radiation on breast tissue is poorly understood with few attempts at modeling the Normal Tissue Complication Probability (NTCP). This study estimates the NTCP parameter values for breast fibrosis after external beam breast radiation therapy (RT).
Materials and Methods: Individual patient data of 5282 patients from the multi-centre EORTC 22881-10882 'boost versus no boost' trial and 574 patients from the Cambridge breast IMRT trial were pooled and analysed. All patients received whole breast irradiation (WBI) (40Gy in 15 fractions over 3 weeks or 50Gy in 25 fractions over 5 weeks) followed by tumour bed (TB) boost in some cases. A two compartment dose volume histogram (DVH) model was used with TB volume receiving WBI plus boost dose as the first compartment and whole breast volume outside the TB volume receiving WBI dose alone as second compartment. Two NTCP models were considered: (a) Lyman Kutcher Burman (LKB) model and (b) Niemierko model. The model parameters (BEUD50, m or γ50 and n)) for moderate-severe breast fibrosis were estimated using the Maximum Likelihood Estimation (MLE) method. To account for hypofractionation, a biologically equivalent dose (BED_3) was generated using α/ß of 3Gy. The parameter 95% confidence intervals (CI) were generated using the Profile Likelihood Estimation method. Summary data from the START pilot trial (n=1410) were used to asses the goodness of fit of the predicted NTCP model using the Pearson chi-square test.
Results: One hundred and fifty four patients (26.8%) in the Cambridge trial and one thousand and ninety six patients (20.7%) in the EORTC trial developed moderate-severe breast fibrosis. Using the MLE method, the best estimated NTCP parameters were $BEUD_3(50)$ =136.4Gy, γ50=0.9 and n=0.011 for the Niemierko model and $BEUD_3(50)$ =132Gy, m=0.35 and n=0.012 for the LKB model. A small value of volume parameter 'n' suggests that for moderate-severe fibrosis, breast tissue is a serial organ. The observed rates of moderate-severe fibrosis in the START pilot trial were in good agreement to the predicted rates from the above models (x^2=0.05; p=0.95 with five degrees of freedom) Figure 1.

Figure 1: Lyman Kutcher Burman Model – The probability of moderate-severe breast fibrosis versus biological equivalent dose using α/β of 3 Gy (BED_3). The solid line is based on the best estimated parameters (BED_3 = 132 Gy and m= 0.35) and the dashed lines are upper and lower 95%CI. The summative toxicity data of the three dose fractionations ± boost at five years from the START pilot trial are plotted.



Conclusions: This large multi-centre pooled study indicates that the effect of volume parameter is small and the maximum radiotherapy dose is the most important parameter to influence late breast fibrosis. Clinical validation of these results from future prospective studies is suggested.

OC-0076
Second cancer risks after radiotherapy for breast cancer : What is the impact of advanced treatment techniques?
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Purpose/Objective: Breast cancer is the most commonly diagnosed female cancer, and with good survival rates, it is imperative that any potential long term side effects from this effective treatment are reduced. Techniques specific to patient cohorts with differing local recurrence risk factors are likely to be the new standard of care in breast radiotherapy in 5 to 10 years. These techniques include simultaneous integrated boost (SIB) and conformal non co-planar beam arrangements for accelerated partial breast irradiation (APBI). These beam arrangements distribute the dose throughout the body in a different pattern to the standard treatment. This work reports a comparison of the risk for these modern radiotherapy techniques, including the use of image guidance.
Materials and Methods: Five treatment plans were created on a patient CT scan: standard whole breast treatment (WBRT), conformal non co-planar five field plan for an APBI treatment, two volume/two dose level SIB plan with 5 fields, three volume/three dose level SIB plan with 7 fields (forward planned), three volume/three dose level SIB plan with 7 fields (inverse planned). The plans were transferred to a whole body phantom. Regions in the phantom which represented radiosensitive organs were delineated and thermoluminescent dosimeters (TLD) used to measure the dose. Dose from a breast imaging kilovoltage cone beam CT protocol was measured with TLD in the same regions. These dose data were used as input into the Biological Effects of Ionising Radiation Report VII models of second cancer induction and lifetime risks calculated for the five treatment classes and intensive imaging regimes.
Results: The lifetime risk data showed that complex radiotherapy techniques did not increase the theoretical risk of second cancer incidence for organs distant from the treated breast, or the contralateral breast where appropriate constraints were applied. SIB treatments were predicted to increase the lifetime risk of second cancer incidence in the lungs compared to standard breast radiotherapy; this was outweighed by the threefold reduction in 5 yr local recurrence risk with adjuvant radiotherapy for a high risk cohort for whom these treatments are appropriate. A lower lifetime risk of second cancer in the contralateral breast was predicted for the APBI method, compared with WBRT. The contribution of imaging dose to the total dose from both treatment and imaging did not exceed 22% for any measured organ.
Conclusions: Modern complex radiotherapy techniques used in breast cancer were not predicted to increase the theoretical risk of second cancer incidence in organs far from the treated breast. Where increases in the lifetime risk of induced second cancer were predicted, these remained small compared to the large reduction in local recurrence risk from receiving RT as a component of treatment.